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PUBLISHED BY AUVSI FOR THE UNMANNED SYSTEMS COMMUNITY

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AUVSI
ASSOCIATION FOR UNMANNED VEHICLE SYSTEMS INTERNATIONAL

VOLUME 28 NO.4 • APRIL 2010

2700 South Quincy Street, Suite 400, Arlington, VA 22206, USA

Agile, Armed, Not so Stubborn:

Preparing for the Next Big Thing in Ground Robots

By Rich Tuttle

As the U.S. government continues its demand for unmanned ground vehicles that have successfully countered roadside bombs in Iraq and Afghanistan, industry is looking to develop the next big thing in ground robotics.

Companies would like to duplicate the success of Foster-Miller's Talon and iRobot's PackBot in the anti-roadside bomb mission, but it's not clear just how large the scope of the mission for the next big thing will be.

Foster-Miller and iRobot themselves are in the hunt. They and other companies, for instance, are working on the idea of putting weapons, lethal and non-lethal, on UGVs.

"There's a lot of potential for these systems because they can provide such improved precision and accuracy versus the soldier himself or herself," says Lindsay Voss, formerly an analyst with Frost & Sullivan who is now a research analyst with AUVSI.

They might also be intimidating. If a machine is clearly armed and you're an enemy fighter, "you're going to get away" if it's clear the machine is armed, or even if you just think it is, she says.

That's one of the benefits of a weaponized UGV, "and one of the things that industry's going after — how do we use these systems on a first approach" to an enemy, she says.

Another area that seems to be growing more popular is "throwbots," or small UGVs that can be thrown through a window or around a corner to assess a situation before troops commit themselves. Such devices are becoming more resilient, for instance, righting themselves more dependably and then going on to whatever location has been designated for them.

But work on more advanced systems is also under way.

Building a Better Mule

Boston Dynamics of Waltham, Mass., for example, has just won a competition to develop the Legged Squad Support System, or LS3, a four-legged vehicle that can move with a squad of troops and carry 400 pounds, well over the load of a soldier or Marine, who are struggling with packs that can reach a back-breaking 120 pounds because they're full of the tools of modern warefare — batteries, computers and radios — in addition to the more familiar weapons, food, ammunition and water.

LS3 would go wherever troops go, on missions covering 20 miles and lasting 24 hours. In Afghanistan, that means up and down mountainous terrain. It also means without human attendance.

"We don't want to take troops away from their standard duty" to control the vehicle, says DARPA's Robert Mandelbaum. DARPA and the U.S. Marine Corps — which now uses old-fashioned mules to carry big loads — are funding the $32 million LS3 development program, which began on 1 Feb.

Marc Raibert, president of Boston Dynamics, says LS3 is an outgrowth of the company's earlier BigDog, which "carried 320 pounds on the flat, went 12 miles and climbed difficult terrain." But, he says, "BigDog did those things one at a time. That is, it could carry 320 pounds if it was walking on the flat, and it could go 12 miles if it wasn't carrying any payload and it could climb if it was carrying a modest payload. I think we did 120 pounds. But when you combine all those together, the increase in functionality is really substantial. It's really a major undertaking to design a machine that can meet those goals."

Boston Dynamics has 30 months to do so. At the end of that period, Raibert tells *Unmanned Sys-*

Boston Dynamics' BigDog, which paved the way for the LS3. Photos courtesy Boston Dynamics.

Lockheed Martin's replacement for the traditional beast of burden, its Mule UGV. Photo courtesy Lockheed Martin.

tems, the company and its teammates — Bell Helicopter, AAI Corp., Carnegie Mellon, the Jet Propulsion Laboratory and Woodward HRT — will have two prototypes. First "walkout" is slated for 2012. "We're confident we're going to come up with a good set of prototypes at the walkout," he says. The prototypes will be identical.

DARPA's Mandelbaum believes the promise of LS3 is great. In an e-mail, he ticks off its advantages over the system Mother Nature provided, namely the mule:

Maintenance during down-time: "Regular mules require continual care, maintenance and feeding even between missions. Robotic systems can simply be turned off while they are not needed. Hence the total maintenance cost can be dramatically lower for LS3.

Logistics: "Robotic vehicles can be designed for easy loading and unloading into transport vehicles; robots require no special quarters on base; robots can be designed to be air-droppable; robots can be easier to maintain — a damaged robot can be fixed overnight with spare parts, whereas a mule may require long convalescence time for injuries or may even need to be euthanized."

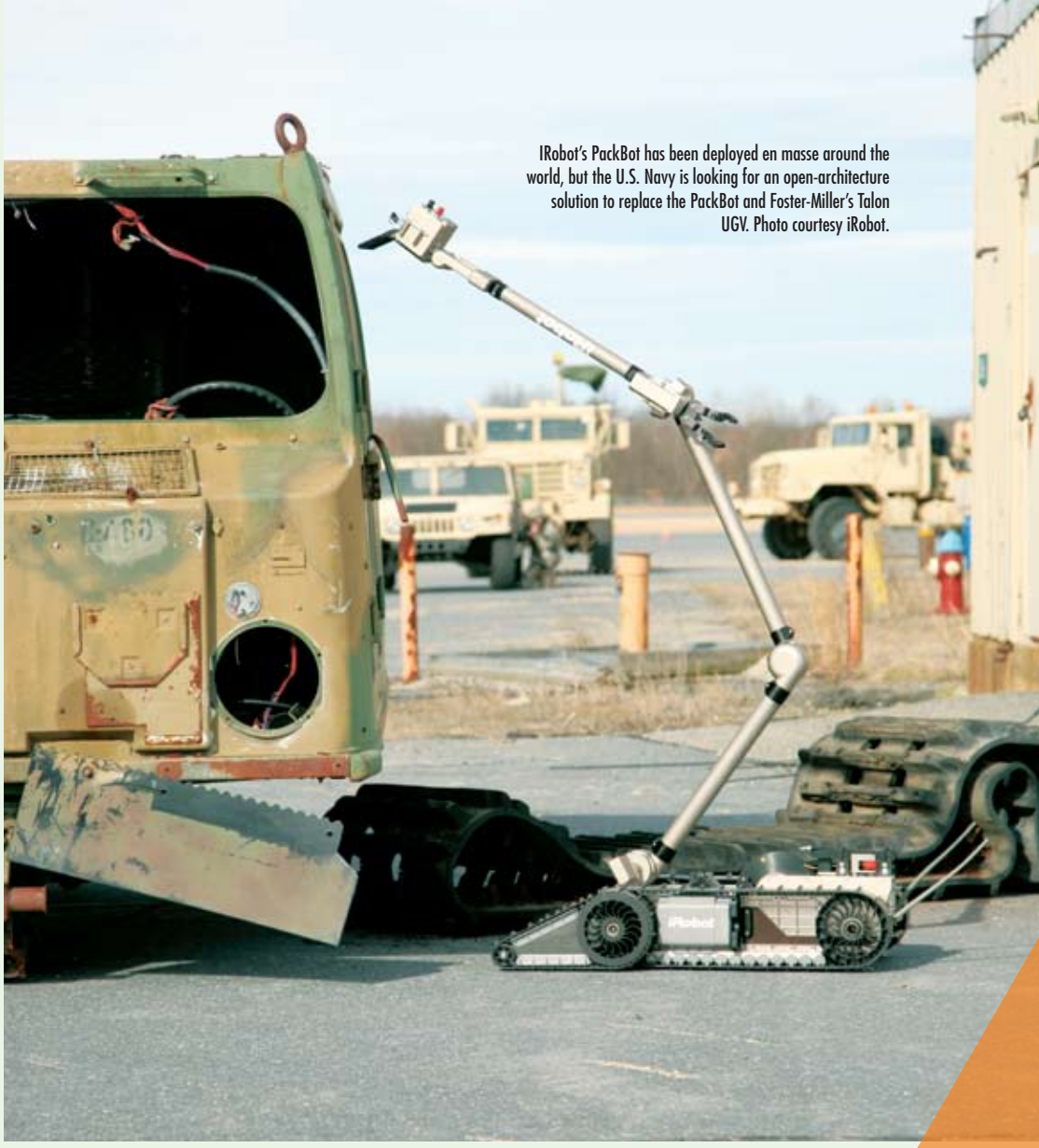
Payload: "Mules can typically comfortably carry approximately 10 percent-20 percent of their body weight (around 200 pounds) the LS3 vehicle will carry double that for approximately the same vehicle weight. Future versions of robotic vehicles will be designed to carry even more. The general trend in technology is that once we figure out how to mimic a functionality in nature, we can usually amplify it greatly (e.g., aircraft carry far more payload than even the largest birds; computers do arithmetic many orders of magnitude faster than humans)."

Adaptability/Range of Missions/Extensibility: "Regular mules require substantial training to perform the basic function of carrying payload. They cannot travel independently without a human leader. Mules cannot be extended to have any other capabilities. Robots, by contrast, will be able to navigate autonomously between GPS waypoints. In addition, future versions of LS3 will be adaptable to a wide range of missions. For example, robots carrying armor can provide cover, and robots with surveillance sensors can provide overwatch. One could conceive of giving LS3 arms so that it could load/unload itself, operate other machinery or perform other tasks requiring manipulation. LS3 is just the beginning. It will provide a platform which is extensible, adaptable and much more versatile and generally capable than a mule."

Obedience: "Robotic vehicles are controlled via a computer interface, including speech, hand gestures, GPS coordinates, etc. In contrast, mules respond only to a small set of pre-trained simple commands."

AEODRS

The U.S. Navy is working on another new unmanned ground vehicle, the Advanced Explosive Ordnance Disposal Robotic System, or AEODRS. It is the next major program for the Navy's Littoral and Mine Warfare Program Executive Office and would ultimately replace the Talon and PackBot systems — of which more than 2,000



IRobot's PackBot has been deployed en masse around the world, but the U.S. Navy is looking for an open-architecture solution to replace the PackBot and Foster-Miller's Talon UGV. Photo courtesy iRobot.

have been deployed to Iraq and Afghanistan and around the world — as well as one from Northrop Grumman that also is designed to defeat improvised explosive devices, or IEDs.

"All three of those systems are basically proprietary systems; they were modified commercial items that have proprietary architecture interfaces," says Byron Brezina, robotics technologist at the Naval EOD Technology Division of Naval Sea Systems Command's Naval Surface Warfare Center at Indian Head, Md. "They were the right choice and the right strategy at the time, and now it's time to really focus on a modular, open systems approach for the future, and that's really what the AEODRS is all about."

A draft capability development document listing requirements that an operational AEODRS must fill is expected to be approved this spring. Once that happens, the effort can proceed to Milestone B, or the system development and demonstration phase, which would begin this summer. Milestone B approval would also elevate AEODRS to the status of "program of record," or official program.

The requirements document, Brezina says, calls for a family of robotic systems — a 35-pound variant that can be carried by a soldier or Marine, a 164-pound model that could be carried by a vehicle and one weighing up to 750 pounds that would be used around a base. The systems of all three would be interoperable through government-controlled interfaces. Subsystems would be interchangeable, and open architecture would allow easy upgrades.

"What's out there now is working," Brezina says. "Could stuff be better? Yes. That's probably true of any military system. But users are not lacking. They have the 80 to 90 percent solution out there now. And there is a robust continuous improvement program for the program of record robots" now in the field. AEODRS is important because when it reaches the field in several years, it will simplify and reduce the cost of logistics, support and upgrades, among other things, he says.

Asked in an e-mail if he is concerned about funding for AEODRS, Brezina says, it "is a planned program of record in response to a formal user requirement that is documented in a Capability Development Document and is funded accordingly. At the same time, immediate warfighter needs are being addressed through the improvement and upgrading of currently fielded UGVs."

He also said technology funded by DARPA translates pretty well into Navy EOD efforts aimed at improving the manipulation capabilities of robotic arms. "We're basically trying [to] let the EOD tech project himself or herself [to the target] and the manipulators we have today, again, they are good for now, but they're basically not very sophisticated and there is no feedback other than visual and audio, for what that's worth."

He says the EOD community is therefore interested in haptics technology — when a manipulator "touches something or grips something, the operator receives that sensation through the control system. That's where you get into things like, hey, if you wanted to pick up an egg, or how hard are you pulling on a critical piece of an IED? And it's a tough problem."

A couple of contracts awarded by the Navy in February re-

flect DARPA's work, Brezina says. One, to HDT Engineering Services Inc. of Fredericksburg, Va., is to develop a manipulator for the government's Highly Dextrous Manipulator for EOD Robots project. The manipulator will be able to lift a 44-pound load at the outer edge of its workspace. The three-year effort will demonstrate a device that approaches the dexterity of a human.

The other contract, to RE2 Inc. of Pittsburgh, Pa., is to develop a "conformal end effector" with three fingers weighing less than five pounds "that can perform agile tasks and can also support loads up to 110 pounds." RE2 will assist the government in integrating the effector with the Highly Dextrous Manipulator.

"The technology that results from both of the projects is expected to transition to the AEODRS Program of Record in FY 2013," Brezina says in an e-mail.

Rich Tuttle is a defense and aerospace writer based in Colorado Springs, Colo., and a longtime contributor to Unmanned Systems.

Arming UGVs, like Foster-Miller has done with its Talon robot, is a priority for many unmanned ground system companies. Photo courtesy Qinetiq North America.